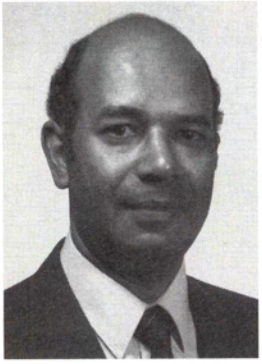
A New Technique to Create Continuity in Prestressed Concrete Members



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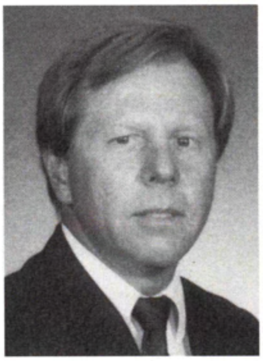

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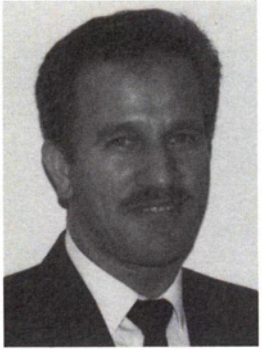

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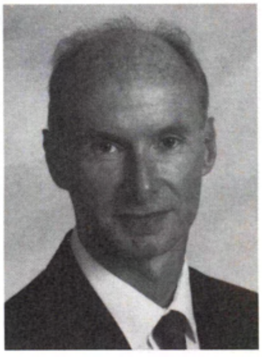

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This paper presents a new technique for creating continuity in prestressed concrete members. The essence of the system is the creation of continuity at interior supports by coupling top end strand extensions. This coupling is followed by introducing compression into cast-in-place joints and tension in the coupled strands. This system has all the benefits of a continuously post-tensioned system without actually implementing the full post-tensioning operation. Members made continuous with this system are expected to exhibit enhanced seismic resistance, superior structural integrity and substantially lower deflection levels than other continuous and non-continuous prestressed concrete members in current use.

Precast, prestressed concrete girders are widely used in the construction of bridges as well as floors and roofs of commercial buildings throughout the world. Depending on the application, spans and loading requirements, these girders are constructed as simple spans, continuous through cast-in-place conventionally reinforced concrete joints, or continuous through full-length post-tensioning.

A new splicing method which offers significant economical and serviceability advantages has been developed. The method was originally conceived at the University of Nebraska at Lincoln (UNL) and jointly developed by Wells Engineers, Inc., and UNL. It has been approved by the Nebraska Department of Roads and implemented into the design of a five-span pedestrian/bicycle overpass in Lin-

coln, Nebraska, described in a companion paper in this issue of the PCI JOURNAL.

This paper presents current girder jointing methods, describes the new method of splicing, presents the testing of a spliced specimen, outlines the advantages of the new method and discusses the economy of the system.

CURRENT SYSTEMS

To facilitate the following discussion, consider an example of a bridge superstructure consisting of prestressed I-girders and cast-in-place deck and joints.

Prior to the introduction of this system, three primary multi-span precast, prestressed concepts have been used extensively:

1. Simply supported members without continuity design

2. Members made continuous via cast-in-place, conventionally reinforced deck and joints

3. Members made continuous by utilizing full-length continuity post-tensioning (see Fig. 1)

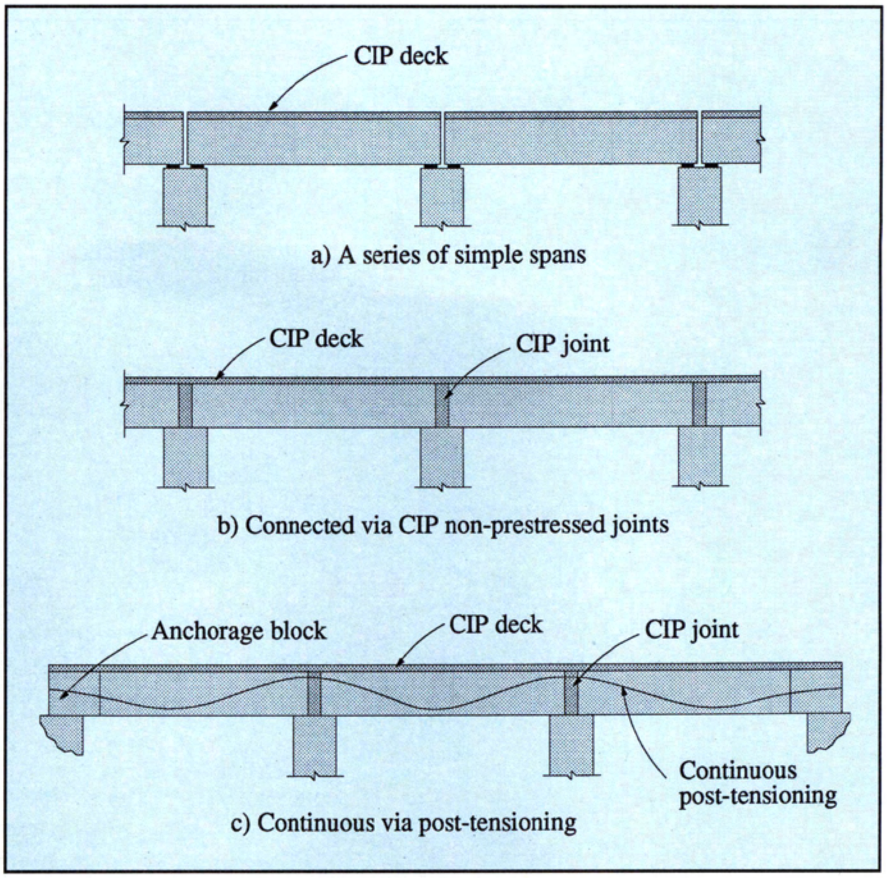

Fig. 1. Various techniques for gaining continuity in precast, prestressed concrete bridges.

The first system (Fig. 1a) is the least desirable of the three when considering structural performance, initial cost and maintenance. The structural advantages afforded by continuity are not utilized. Flexural demands at midspan require the use of appropriate prestressing to counter tensile stresses and to provide adequate ultimate flexural strength. This usage results in higher initial and final camber and, hence, more upward deviation of member top surface from the intended final grade — a definite disadvantage in bridge structures where a "roller-coaster" driving surface is not desirable. Another disadvantage is the rapid deterioration of movement (expansion) joints at the supports due to penetration of water and deicing chemicals.

The second system (Fig. 1b) provides for continuity, but *only* for loads applied after the deck becomes composite with the girders (i.e., superimposed dead loads and live plus impact loads). Thus, this system has some of the same shortcomings as the first system, but to a lesser degree. It requires relatively high amounts of prestressing which could result in excessive camber. In addition, the lack of interior joint precompression is a problem with this system; without precompression, the deck concrete cracks in the vicinity of the joint. The cracks then propagate and widen, and deicing salts, water and other deleterious materials collect in the cracks. This collection and subsequent penetration results initially in the corrosion of some joint reinforcement, is followed by the deterioration of concrete joint materials due to the spalling initiated by the reinforcement corrosion, and ultimately results in the degradation of all concrete and reinforcing materials at or near the joint.

The third system (Fig. 1c) is the most efficient of the three systems, providing relatively low levels of pretensioning and initial camber, continuity at interior support joint locations for all loads except member self-weight, and precompression of interior joint concrete. This system provides all these advantages but at a premium cost. It requires a specialty contractor to facilitate post-tensioning; it requires uniform widening of girder webs to accommodate post-tensioning ducts and local widening of girder webs (i.e., end blocks) at all anchorage locations; it requires special reinforcement at all anchorage locations to accommodate stress concentrations; and it requires special construction sequencing.

SYSTEM CONCEPT

The new system accomplishes all that a pretensioned/post-tensioned precast concrete system does, but in a simpler, more direct manner. The system utilizes pretensioned precast members with strand profiles optimized to "balance" external loads; top strands at adjacent, interior member ends coupled to provide continuity prior to deck placement; and precompression of interior cast-in-place concrete joints. Two methods may be used to achieve the interior joint continuity and precompression.

The first method involves the following steps (see Fig. 2a):

1. Erect pretensioned precast members with top strands extending be-

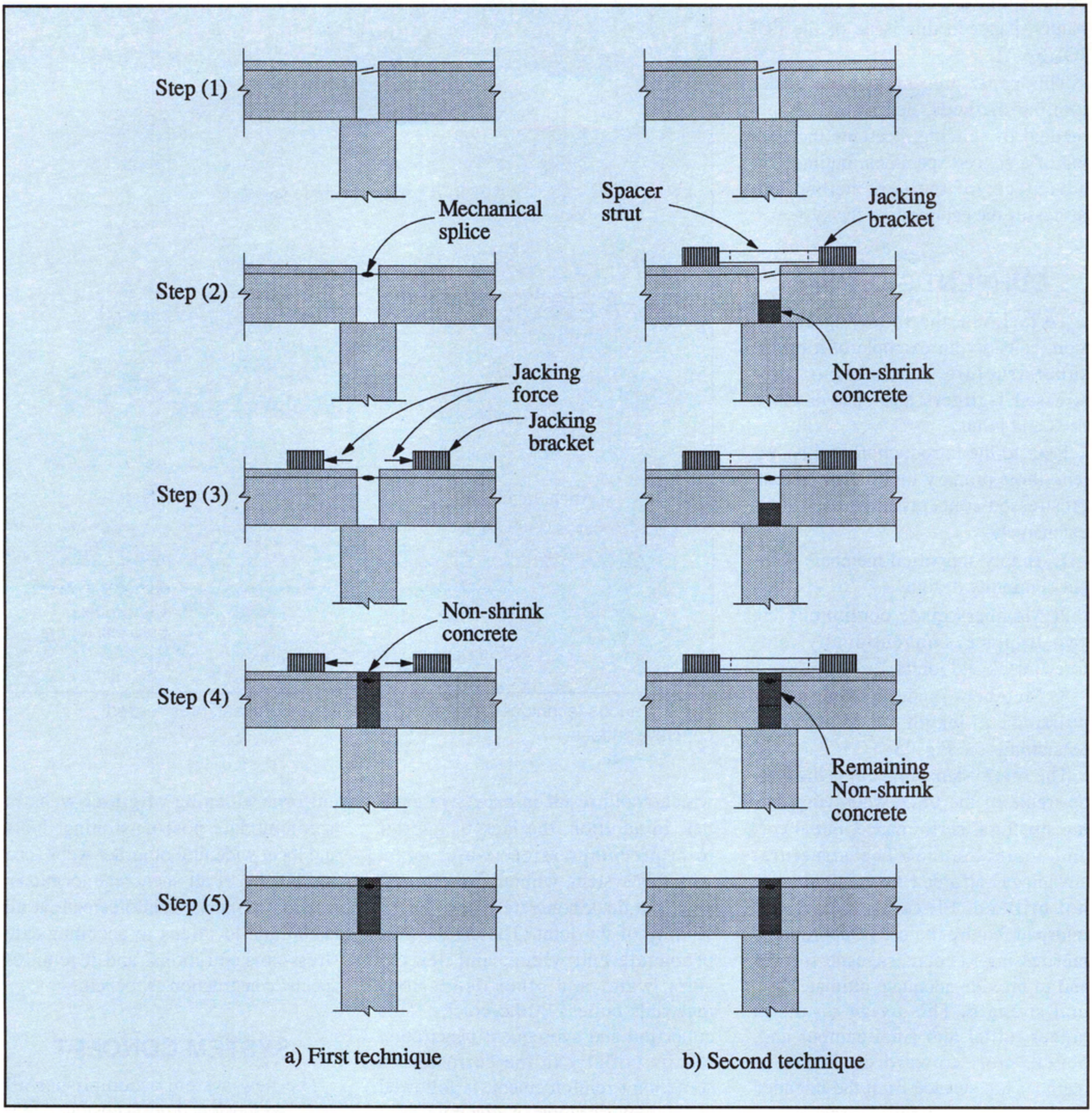

Fig. 2. Two equivalent techniques for splicing precast, prestressed concrete girders.

yond member ends at interior joints. Strand extensions must be of sufficient length to permit their appropriate cutting for staggered splicing (see Figs. 3b and 3c).

2. Splice the strand extensions using mechanical splices supplied with contiguous hardware to allow for slack recovery. Depending on the type of mechanical connector used, it is possible to partially pre-install the splice in the precast concrete plant. Uniformly tighten all coupled strands via the slack recovery hardware.

3. Using appropriate jacking apparatus, push the ends of joined members outward to simultaneously introduce appropriate tensile forces into *all* coupled strands in the joint.

4. Form, pour and cure concrete joint materials. Concrete with high early strength and low shrinkage properties is desirable. The jacking apparatus must maintain appropriate tensile force levels during this stage.

5. Once joint concrete has attained satisfactory strength, introduce precompression into joints by releasing jacking force. Remove all jacking apparatus, including brackets and miscellaneous hardware.

The second method involves the following steps (see Fig. 2b):

1. Erect pretensioned precast members with top strands extending beyond member ends at interior joints. Strand extensions must be of sufficient length to permit their appropriate cutting for staggered splicing.

2. Install appropriate brackets and space struts at both the top and bottom of girders to maintain end positions